

# LIQUID CRYSTAL DISPLAY

## BACKGROUND OF THE INVENTION

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### Field of the Invention

This invention relates to a liquid crystal display, and more particularly to a liquid crystal display with a gate  
10 line structure that can serve as a storage electrode and a black matrix and perform a repair function.

### Description of the Related Art

15 Generally, a liquid crystal display (LCD) controls a light transmissivity using an electric field to display a picture. To this end, the LCD includes a liquid crystal panel having liquid crystal cells arranged in a matrix type, and a driving circuit for driving the liquid crystal  
20 panel. The liquid crystal panel is provided with pixel electrodes for applying an electric field to each liquid crystal cell, and a reference electrode, that is, a common electrode. Typically, the pixel electrodes are provided on a lower substrate for each liquid crystal cell, whereas  
25 the common electrode is integrally formed on the entire surface of an upper substrate. Each of the pixel electrodes is connected, via source and drain terminals of a thin film transistor (TFT) used as a switching device, to any one of data lines. A gate terminal of each TFT is  
30 connected to any one of gate lines for applying a pixel voltage signal to pixel electrodes for one line.

Referring to Fig. 1, there is shown a thin film transistor

substrate of the conventional liquid crystal display (LCD). The LCD includes thin film transistors 6 positioned at intersections between data lines 2 and gate lines 4, and pixel electrodes 14 connected to drain electrodes 12 of the thin film transistors 6. The thin film transistor 6 is provided at an intersection between the data line 2 and the gate line 4. The thin film transistor 6 has a gate electrode 10 connected to the gate line 4, a source electrode 8 connected to the data line 2, and a drain electrode 12 connected, via a first contact hole 16, to the pixel electrode 14. The thin film transistor 6 further includes a semiconductor layer (not shown) for providing a conductive channel between the source electrode 8 and the drain electrode 12 by a gate voltage applied to the gate electrode 10. Such a thin film transistor 6 responds to a gate signal from the gate line 4 to selectively apply a data signal from the data line 2 to the pixel electrode 14. The pixel electrode 14 is positioned at a cell area divided by the data line 2 and the gate line 4, and is made from an indium tin oxide (ITO) material having a high light-transmissivity. The pixel electrode 14 generates a potential difference from a common transparent electrode (not shown) provided at the upper substrate by a data signal applied via the first contact hole 16. By virtue of this potential difference, a liquid crystal positioned between the thin film transistor substrate and the upper substrate is rotated by its dielectric anisotropic property and a light applied, via the pixel electrode 14, from a light source is transmitted into the upper glass substrate. A storage capacitor 18 provided between the pixel electrode 14 and the gate line 4 at the previous stage plays a role to prevent a voltage variation in the pixel electrode 14 by charging a voltage in a period at

which a gate high voltage is applied to the previous-stage gate line 4 and discharging the charged voltage in a period at which a data signal is applied to the pixel electrode 14. Since the storage capacitor 18 aims at  
5 maintaining a stable pixel voltage as mentioned above, it must have a high capacitance value. To this end, the storage capacitor 18 has a structure as shown in Fig. 2. In Fig. 2, the storage capacitor 18 is defined by a storage electrode 20 electrically connected, via a second  
10 contact hole 22 formed in a protective film 28, to the pixel electrode 14 and a gate electrode 4 having on a gate insulating layer 26 therebetween. The storage electrode 20 is formed on the gate insulating layer 26 upon formation of the data line 2 and the source/drain electrode 8 and 12.  
15 As a liquid crystal panel goes into a larger dimension, a capacitance value of the storage capacitor 18 must be more enlarged. However, the above-mentioned LCD structure has a limit in enlarging a capacitance of the storage capacitor 18.

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The protective film 28 of the thin film transistor substrate is usually made from an inorganic material having a dielectric constant such  $\text{SiN}_x$  or  $\text{SiO}_x$ . The pixel electrode 14 and the data line 2 having such an inorganic  
25 protective film therebetween maintain a certain horizontal distance  $d$  (e.g., 3 to  $5\mu\text{m}$ ) as shown in Fig. 3 so as to minimize a coupling effect caused by a parasitic capacitor. In this case, in order to shut off a light leaked through the space between the data line 2 and the pixel electrode  
30 14, a black matrix formed on the upper substrate has a width enough to cover a portion of the pixel electrode 14 positioned at each side of the data line 2. As a result, an aperture ratio of the liquid crystal cell is inevitably

reduced.

### SUMMARY OF THE INVENTION

5 Accordingly, it is an object of the present invention to provide a liquid crystal display that is capable of enlarging a capacitance value of a storage capacitor.

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10 A further object of the present invention is to provide a liquid crystal display that is capable of reducing a width of a black matrix to increase an aperture ratio as well as performing a repair function upon break of a data line.

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15 In order to achieve these and other objects of the invention, a thin film transistor substrate in a liquid crystal display according to the present invention includes a gate dummy pattern formed in such a manner to be extended in the vertical direction from the gate line and to overlap with the data line and the pixel electrode.

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### BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects of the invention will be apparent from the following detailed description of the embodiments of the present invention with reference to the accompanying drawings, in which:

25 Fig. 1 is a plan view showing a structure of a thin film transistor substrate in a convention liquid crystal display;

30 Fig. 2 is a section view of the storage capacitor part taken along the A-A' line in Fig. 1;

Fig. 3 is a section view of the data line part taken along the B-B' line in Fig. 1;

Fig. 4 is a plan view showing a structure of a thin film transistor substrate according to a first embodiment of the present invention;

Fig. 5 is a section view of the data line part taken along the A-A' line in Fig. 4;

Fig. 6 is a plan view showing a structure of a thin film transistor substrate according to a second embodiment of the present invention; and

Fig. 7 is a plan view showing a structure of a thin film transistor substrate according to a third embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 4, there is shown a thin film transistor substrate in a liquid crystal display (LCD) according to a first embodiment of the present invention. The LCD includes thin film transistors 6 positioned at intersections between data lines 2 and gate lines 4, pixel electrodes 14 connected to drain electrodes 12 of the thin film transistors 6, and gate dummy patterns 30 overlapping with the data lines 2 and the pixel electrodes 14 adjacent to the data lines 2. The thin film transistor 6 has a gate electrode 10 connected to the gate line 4, a source electrode 8 connected to the data line 2, a drain electrode 12 connected, via a first contact hole 16, to the pixel electrode 14, and a semiconductor layer (not shown) for providing a conductive channel between the source electrode 8 and the drain electrode 12 by virtue of a gate voltage applied to the gate electrode 10. Such a thin film transistor 6 responds to a gate signal from the gate line 4 to selectively apply a data signal from the data line 2 to the pixel electrode 14. The pixel electrode

14 generates a potential difference from a common transparent electrode (not shown) provided at the upper substrate by a data signal applied via the first contact hole 16. By virtue of this potential difference, a liquid crystal positioned between the thin film transistor substrate and the upper substrate is rotated by its dielectric anisotropic property and a light applied, via the pixel electrode 14, from a light source is transmitted into the upper glass substrate. A storage capacitor 18 provided between the pixel electrode 14 and the gate line 4 at the previous stage plays a role to prevent a voltage variation in the pixel electrode 14 by charging a voltage in a period at which a gate high voltage is applied to the previous-stage gate line 4 and discharging the charged voltage in a period at which a data signal is applied to the pixel electrode 14. The storage capacitor 18 is defined by a storage electrode 20 electrically connected, via a second contact hole 22 formed in a protective film 28, to the pixel electrode 14 and a gate electrode 4 having a gate insulating layer 26 therebetween. The storage electrode 20 is formed on the gate insulating layer 26 upon formation of the data line 2 and the source/drain electrode 8 and 12. The gate dummy pattern 30 overlaps with the data line 2 and the adjacent pixel electrode 14 to serve as a black matrix as well as to perform a repair function upon break of the data line. For instance, the gate dummy pattern 30 is electrically connected to a broken data line 2 by a laser welding technique upon break of the data line 2 to permit a repair. Also, the gate dummy pattern 30 is positioned in such a manner to overlap, by about 0.5 to 1 $\mu$ m, with the data line 2 and the pixel electrode 14, thereby serving as a black matrix for shutting off a light leaked between the data

line 2 and the pixel electrode 14. When the gate dummy pattern 30 is used as a black matrix as mentioned above, an area overlapping with the pixel electrode 14 can be more reduced in comparison to the conventional black matrix to expect an aperture ratio increase of about 5 to 6%. To this end, the gate pattern 30 is formed on a lower substrate 24 with having the gate insulating layer 26 at each side of the data line 2 as shown in Fig. 5. This gate dummy pattern is made from the same material (e.g., Al, Mo, Ti, W, Cr or Cu) as the gate line and the gate electrode. Such a gate dummy pattern 30 may be provided at both sides of the data line 2 or at one side of the data line 2. If the gate dummy pattern 30 is electrically connected to the gate line 4, then it can be used as a storage electrode forming the storage capacitor along with the pixel electrode 14 overlapped with having the gate insulating layer 26 and the protective film 28 therebetween. In this case, a capacitance value of the storage capacitor caused by the gate dummy pattern 30 is added to the conventional storage capacitor 18, so that a voltage of the pixel electrode 14 can be maintained at more stable state.

Referring to Fig. 6, there is shown a thin film transistor substrate in a liquid crystal display (LCD) according to a second embodiment of the present invention. The thin film transistor substrate of Fig. 6 has the same elements as that of Fig. 4 except that a gate dummy pattern 32 is electrically connected to a gate line 4. The gate dummy pattern 32 is extended from the gate line 4 into the lower portion thereof in such a manner to overlap with a data line 2 and a pixel electrode 14 at each side of the data line 2. Such a gate dummy pattern 32 defines a second storage capacitor along with the pixel electrode 14

overlapped with having a gate insulating layer and a protective film. As a result, a capacitance value of the second storage capacitor caused by the gate dummy pattern 32 is added to the existent storage capacitor, that is, the first storage capacitor 18, so that a voltage at the pixel electrode 14 can maintain more stable state. In addition, the gate dummy pattern 32 permits a repair upon break of the data line 2. In order to provide a repair of the data line 2, it must be opened to the gate line 4. However, when the gate line 4 and the gate dummy pattern 32 is cut by means of a laser, the data line 2 overlapping with the gate dummy pattern 32 also is cut away. In order to prevent a damage of the data line 2, a hole 32a is provided at a cutting part for breaking the gate line 4 and the gate dummy pattern 32 in such a manner to be not overlapped with the data line 2 as shown in Fig. 6. Accordingly, upon break of the data line 2, a repair can be performed by cutting the hole 32a provided in the gate dummy pattern 32 using a laser to electrically break the gate line 4 from the gate dummy pattern 32 and thereafter electrically connecting the broken data line 2 to the gate dummy pattern 32 using the laser welding technique. Also, the gate dummy pattern 32 is positioned in such a manner to overlap, by about 0.5 to 1 $\mu$ m, with the data line 2 and the pixel electrode 14, thereby serving as a black matrix for shutting off a light leaked between the data line 2 and the pixel electrode 14. When the gate dummy pattern 32 is used as a black matrix as mentioned above, an area overlapping with the pixel electrode 14 can be more reduced in comparison to the conventional black matrix to expect an aperture ratio increase of about 5 to 6%.

Referring to Fig. 7, there is shown a thin film transistor



substrate in a liquid crystal display (LCD) according to a third embodiment of the present invention. The thin film transistor substrate of Fig. 7 has the same elements as that of Fig. 4 except that a protrusion 2a is provided at a data line 2 so as to shut off a light leaked between a gate line 4 and a gate dummy pattern 30. The gate dummy pattern 30 formed at the same layer as the gate line 4 overlaps with a data line 2 and a pixel electrode 14 at each side of the data line 2 to serve as a black matrix for shutting off a light leaked between the data line 2 and the pixel electrode 14. In this case, in order to prevent a light from being leaked through a spaced area between the gate line 4 and the gate dummy pattern 30, the data line 2 further includes a protrusion 2a overlapping with the gate line 4 and the gate dummy pattern 30. When the gate dummy pattern 30 and the protrusion 2a of the data line 2 are used as a black matrix as mentioned above, an area overlapping with the pixel electrode 14 can be more reduced in comparison to the conventional black matrix to expect an aperture ratio increase of about 5 to 6%. Also, the gate dummy pattern 30 permits a repair upon break of the data line 2. More specifically, the gate dummy pattern 30 is electrically connected to a broken data line 2 by the laser welding technique, etc. upon break of the data line 2 to permit a repair. If the gate dummy pattern 30 is electrically connected to the gate line 4, then it can be used as a storage electrode forming the storage capacitor along with the pixel electrode 14 overlapped with having the gate insulating layer 26 and the protective film 28 therebetween. In this case, a capacitance value of the storage capacitor caused by the gate dummy pattern 30 is added to the conventional storage capacitor, 18, so that a voltage of the pixel electrode 14

can be maintained at ~~more~~ stable state.

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As described above, according to the present invention, the gate dummy pattern branched from the gate line and overlapping with the edge of the pixel serves as a storage electrode to increase a storage capacitance value. Accordingly, since a storage capacitance value increased by virtue of the gate dummy pattern compensates for an average maintenance voltage  $V_{rms}$  between the pixels generated by a characteristic difference between the thin film transistors caused by a misalignment of the line patterns in the course of a process to improve a picture quality, the present LCD is adaptive for a technique of fabricating a large-dimension LCD. Furthermore, according to the present invention, the gate dummy pattern branched from the gate line and overlapping with the edge of the pixel serves as a black matrix to more increase an aperture ratio in comparison to a case where the conventional black matrix is used. In addition, the gate dummy pattern branched from the gate line and overlapping with the edge of the pixel is used to permit a repair upon break of the data line, so that an effect of a throughput improvement can be obtain.

25 Although the present invention has been explained by the embodiments shown in the drawings described above, it should be understood to the ordinary skilled person in the art that the invention is not limited to the embodiments, but rather that various changes or modifications thereof are possible without departing from the spirit of the invention. Accordingly, the scope of the invention shall be determined only by the appended claims and their equivalents.